CHAPTER 6

OPERATIONS AND MAINTENANCE

6-1. Introduction. This chapter addresses IAS construction, operations, and maintenance issues. Operations and maintenance for an IAS system fall into two primary categories: remediation progress monitoring and mechanical system maintenance.

6-2. Construction Oversight.

a. The construction of an air sparging system consists of well installation, piping and wiring installation, and placement of the compressor(s) or blower(s) and accessories. The construction of an air sparging system is comparable to the installation of a soil vapor extraction system. EP 415-1-261 (Volume 5, Chapter 6) contains specific information on construction of soil vapor extraction systems that can be applied directly to oversight of installation of various components of air sparging systems. In particular, the guidance contained in that chapter is applicable to piping installation and above-ground equipment installation.

b. Refer to EP 415-1-261 (Volume 4, Chapter 2) for information applicable to the installation of air sparging wells. Unlike Chapter 6 of the same document, this chapter addresses the construction of extraction and monitoring wells below the water table. Notably, well seal placement is a critical aspect of air sparging well construction and should be observed in the field. Without a good well seal, there is a potential for air to “short circuit” to the water table along the casing.

6-3. O&M Strategy.

a. The primary considerations in preparing an operations and maintenance plan include:

(1) achieving remediation success as expeditiously as possible;

(2) preventing further environmental impacts via waste streams or contaminant mobilization;

(3) maximizing the lifetime of the IAS mechanical system;

(4) collecting sufficient data to support these considerations; and

(5) minimizing costs to achieve these considerations.

b. The designs of a majority of IAS systems are based on a limited amount of site-specific information. Additionally, a range of system operating behaviors typically occurs during the life span of a project.

Therefore, it is important that flexible operational guidelines be incorporated into site specific procedures developed to ensure optimum IAS system performance.

c. Proper operation of an IAS system requires on-going monitoring and system adjustments. If the system is not operated properly, the groundwater plume may migrate off-site. Although air emissions from some IAS/SVE systems can exceed those from SVE operating without IAS, in other cases IAS systems may dilute vapor being collected by an SVE system. This may occur because while concentrations in the groundwater may be above standards, the groundwater may contain much less contaminant mass than the overlying vadose zone. An evaluation should be performed to estimate emissions, with the system operator procuring necessary permits or installing emission controls as required. An alternative that may minimize the need for permitting and/or controls is cycling the IAS operation, as will be discussed in paragraph 6-6b.

6-4. O&M Guidance - Below Grade Components. Subsurface IAS components, as previously discussed, consist of injection/extraction wells, and data acquisition probes which may include monitoring wells, various detectors, and soil gas monitoring points. Minimal maintenance techniques are available for most of these components, short of removal and reinstallation.

a. Injection Wells.

(1) A consideration for IAS should be the potential for well screen and aquifer fouling via precipitation of metals (primarily iron) or microbial growth. Although fouling does not appear to be a major problem, its potential is not clearly established, and in part is a function of the redox potential of the injectant, aquifer alkalinity, and the type and abundance of organic complexing compounds. The reader is referred to other USACE guidance on dealing with well fouling. Screen fouling has been addressed via physical agitation, and chemical and thermal treatments. Mineral deposits on well screens can be removed using low pH solutions such as hydrochloric or sulfuric acid. Iron bacteria can be removed by introducing bacteriacides (e.g., chlorine dioxide), followed by low pH treatment after the chlorine is removed from the well. Recommended procedures for chlorine control of iron bacteria are detailed in Driscoll (1986).

(2) High-temperature pasteurization has also been used to control iron bacteria in groundwater. Consideration of the thermal limitations of well completion materials should be made if high-temperature pasteurization is employed. Special considerations must be used for applying these techniques to IAS, as the fluid and flow directions are opposite those of supply wells, and fouling will occur on the substrate side of the screen, making foulant removal difficult. Oxidants injected to remove fouling in the wells may cause fouling in the aquifer. Additionally, contaminant mobilization and killing of contaminant degraders are concerns. In some cases well replacement is the most effective approach to deal with well fouling. Placing screened intervals

below the zone of contamination may reduce biofouling. SVE wells typically are not subject to screen fouling if they are properly constructed and screened sufficiently above groundwater.

(3) Strategies for minimizing the biofouling associated with the concurrent injection of electron receptors (e.g., oxygen in air) and nutrients (e.g., NO_2) have been reported by Taylor and Jaffe (1991). Although their research focused on in-situ biodegradation, they report that sediments characterized by a high porosity, poor sorting, and a small maximum pore radius are most susceptible to biofouling. By alternatively pulsing the electron donor and acceptor, the propensity for biofouling is reduced. In addition, by increasing the oxygen concentration in the injection water, increasing the discharge rate, and delivering the oxygen through multiple injection wells, bioremediation efficiency was increased without causing excessive biofouling (Taylor and Jaffe 1991).

b. Monitoring Wells and Piezometers. Monitoring wells should be purged prior to sampling, in accordance with standard groundwater sampling methods (Puls and Barcelona 1996). Purging typically entails removing groundwater while monitoring physical/chemical parameters such as pH, temperature, conductivity and/or dissolved oxygen to indicate equilibration (equilibration implies that the purged water is representative of the formation groundwater). Purging soil gas monitoring points is not as clearly defined in standard operating procedures, but should be applied in a similar fashion to the principles which guide groundwater sampling. Soil gas points are typically purged using a diaphragm pump equipped with a moisture knockout vessel. Rotary vane pumps require lubricating oil and are not recommended. Soil gas can be analyzed by connecting appropriate detectors directly to the point tubing, or by collecting a soil gas sample in a low gas permeability container such as a Tedlar® bag. Monitoring wells and piezometers typically do not require maintenance for the life of an IAS system operation, other than the replacement or repair of failed surface components such as connectors; however, monitoring wells can silt up, as can IAS wells (especially under pulsing), and therefore may require redevelopment. Guidance on soil gas sampling is also provided in ASTM D5314-92.

c. Detectors.

(1) Subsurface detectors such as in-situ oxygen detectors and pressure transducers require no maintenance short of removal for repair or replacement. The operation of each type of unit is specific to the manufacturer's specifications. Pressure transducers are often connected to surface dataloggers installed in weathertight boxes for extensive or long-term pressure profiling. Over the course of long-term monitoring, membrane-fouling in oxygen detectors should be anticipated, which may require cleaning/replacement every few weeks.

(2) To ensure that vapors produced by IAS do not migrate into nearby buildings, basements, mechanical pits, etc., installation and monitoring of

site specific contaminant sensors and/or observation of differential pressures exterior to such structures versus within them may be advisable.

d. Baseline Measurements. The operator should collect baseline data from a minimum of two (2) distinct time intervals to allow for proper effectiveness evaluations. Prior to start-up of the IAS system, the following baseline measurements should be collected from monitoring locations at the site:

(1) groundwater levels;

(2) water quality measurements (VOC concentrations, dissolved oxygen, temperature, conductivity, pH and biomonitoring parameters, if desired, such as ammonia nitrogen (NH_3), nitrate nitrogen (NO_3) and carbon dioxide (CO_2);

(3) soil gas VOCs, O_2 and CO_2 concentrations;

(4) subsurface pressures (with the SVE system off, if applicable), to assess the magnitude of barometric fluctuations;

(5) existing SVE system operational parameters including flow rates and vacuum distribution (if applicable); and

(6) SVE system discharge VOC concentrations (if applicable).

6-5. Operation and Maintenance Guidance - Precommissioning and Start-up.

a. General.

(1) A start-up workplan should be developed prior to system precommissioning and start-up. The workplan should include objectives of the IAS system and the strategy, procedures and monitoring requirements for start-up and continued operation. The start-up workplan should be a flexible document that will allow for unexpected changes in the field.

(2) If chemical adhesives were used during construction, the VOCs should be purged from the system by opening IAS wellheads and valves and injecting air into the manifold lines with a compressor, and discharging the vapors into a treatment system if necessary. Air purging should last a minimum of 10 minutes and run until results from an OVA or similar device indicates that all VOCs have been purged. This will allow VOCs to discharge into the atmosphere rather than the groundwater when the system begins operation.

(3) The system operator should run the SVE system (if present) until contamination levels have decreased and stabilized. Operating the SVE system before starting up the IAS system has two purposes: 1) to establish a capture zone; and 2) to accommodate the elevated VOC concentrations that often accompany initiation of SVE prior to capture of the additional IAS-generated

VOCs, the combination of which may otherwise be initially in excess of off-gas treatment capacity. IAS operations should then begin. This will maximize efficiency between the SVE and IAS systems.

b. Start-up Procedure. Table 6-1 provides a checklist for operators prior to beginning start-up services. Table 6-2 outlines procedures for IAS system start-up after completion of manifold air purging. If any well requires more air pressure than the designed operating pressure, or if the delivery pressure of the air supply source is inadequate, system repairs or redesign may be required. Manifold lines can be tested either hydrostatically or with air to evaluate potential leakage.

6-6. IAS System Operation, Maintenance and Monitoring.

a. General.

(1) Increases in air injection flow rates will increase the rate of remediation at most sites up to a point of diminishing returns. Therefore, it may not be cost-effective to operate the IAS system at the maximum flow rate, because the presence of diffusion limitations will affect the efficiency of an IAS system. As previously discussed, the five main factors limiting the rate of air injection are soil matrix considerations, IAS mechanical supply source limitations, SVE equipment limitations, biological (in-situ bioremediation) limitations and preferential air migration. Based on limitations present at specific sites, two separate operational approaches can be used and are referred to as "continuous" and "pulsed". Whichever operating strategy is selected, on-going system monitoring is required to ensure efficient operations. The following sections present checklists for IAS system monitoring. Likewise, the system operator should refer to EM 1110-1-4001 for a similar checklist for the SVE system, if used. These checklists should be completed at appropriate time intervals but at least weekly.

(2) Groundwater monitoring during IAS operation provides data necessary to assess the performance of the system. A typical IAS system is monitored for some or all of the following performance parameters:

(a) dissolved oxygen (measured via low-flow pumping and a flow-through cell or a downhole probe);

(b) air saturation in the treatment area (measured via neutron access probes, ERT or TDR);

(c) soil gas chemical parameters (i.e., VOCs or tracer gas);

TABLE 6-1

Suggested Precommissioning Checklist

Checklist Item	N/A	MR	AN	Recommended Action	Responsible (Initials)	Target Complete Date	Comments
SUBSURFACE							
IAS/SVE Wells							
Soil physical and chemical characteristics established							
IAS wells/trenches installed per specification (e.g., screen length, size, diameter, depth, filter pack, grout, seal, riser)							
SVE wells/trenches installed per specification (e.g., screen length, size, diameter, depth, filter pack, grout, seal, riser)[1]							
IAS wells purged/cleaned/developed							
Monitoring locations established (e.g., neutron access tubes, ERT boreholes, groundwater monitoring wells, piezometers, and soil gas probes)							
IAS well and monitoring locations surveyed and located on layout plan							
SVE well and monitoring locations surveyed and located on layout plan							
Groundwater access ports installed at each IAS well							
SVE sample ports installed at each well							
IAS airflow control provided at each well head							

TABLE 6-1 (Cont'd)

Suggested Precommissioning Checklist

Checklist Item	N/A	MR	AN	Recommended Action	Responsible (Initials)	Target Complete Date	Comments
SVE airflow control provided at each well head							
Baseline monitoring data collected (e.g., dissolved oxygen, Eh, VOCs)							
IAS/SVE Piping							
IAS underground piping to pumps installed per specifications (e.g., size, material type, location, depth, etc.)							
SVE underground piping to pumps installed per specifications (e.g., size, material type, location, depth, etc.)							
Piping insulation/heat tape installed							
Piping flushed/cleaned/pressure tested							
Subsurface as-built equipment schematic provided							
SURFACE							
IAS/SVE Mechanical/Civil							
IAS surface equipment schematic shown (including pressure tanks and compressor)							
SVE surface equipment schematic shown (including blower)							
IAS foundations complete							
SVE foundations complete							
IAS compressor provided and installed per specifications							
SVE blower provided and installed per specifications							

TABLE 6-1 (Cont'd)

Suggested Precommissioning Checklist

Checklist Item	N/A	MR	AN	Recommended Action	Responsible (Initials)	Target Complete Date	Comments
SVE sample ports installed upstream and downstream of blower							
IAS compressor(s) grouted in place							
SVE blower(s) grouted in place							
IAS vibration dampers installed							
SVE vibration dampers installed							
IAS coupling alignment/level to specifications							
SVE coupling alignment/level to specifications							
IAS compressor/pipe connections installed/tested							
SVE blower/pipe connections installed/tested							
IAS compressor and seal integrity verified							
SVE blower and seal integrity verified							
Silencers installed before and/or after IAS compressor							
Silencers installed before and/or after SVE blower							
SVE air/water separator provided							
IAS air filtered for oil and particulates							
IAS piping layout provided (as practical and economical)							

TABLE 6-1 (Cont'd)

Suggested Precommissioning Checklist

Checklist Item	N/A	MR	AN	Recommended Action	Responsible (Initials)	Target Complete Date	Comments
SVE offgas treatment installed and functional (if needed)							
Auxiliary fuel operational (if needed)							
Aftercooler system functional (if needed)							
IAS/SVE Electrical							
System grounding installed/checked							
Enclosure lighting/HVAC functional							
Pump rotation verified							
Disconnects in sight of units being controlled							
Power connected to monitoring instruments							
Instrumentation/Controls							
Valves (including air bleed, dilution, and check valves) installed and operation verified							
Temperature, pressure and flow gauges installed in piping upstream (if necessary) and downstream of compressor/blower							
Gauges calibrated, tested, and readings in range							
Control/alarms and interlocks functional							

(1) Italicized text identify components associated with SVE systems.
N/A Indicates not applicable
MR Meets requirements
AN Action Needed

TABLE 6-2

IAS System Start-up Procedures[1]

1	Turn on the air source, regulate from a lower pressure to the necessary pressure to attain the design air flow rate for the chosen well group or entire system (as appropriate). DO NOT EXCEED THE MAXIMUM RECOMMENDED AIR PRESSURE. Measure SVE system emissions, if applicable, with appropriate field instruments to verify permit limits are not exceeded.
2	Balance the flow to each well (through adjustment of appropriate valves) as each well may behave differently. If solenoid valves are not used, the operator should use pressure gauges and flow meters to measure and balance air flows.
3	Develop a flow vs. pressure (F/P) curve for each well. The generated F/P curve (which is dependent on water table position) allows determination of well flow rate based upon wellhead pressure measurements. This approach reduces the effort required during routine site measurements.
4	Verify the air compressor and manifold line pressure and total injection flow rate, following the balancing of the wells. Although the agreement between sum of individual well flows and total flow measurement will be approximate, any significant deficiencies will be apparent at this time. A quick check to determine an agreement between total air compressor flow and the cumulative flow as measured at each of the wells is advised.
5	Sample the SVE system inlet, if present, and exhaust streams with an OVM or other appropriate field instrument and analyze over the entire start-up period.
6	Check for bubbling in monitoring wells and piezometers at the site. If bubbling is observed, operators should install air-tight caps on these wells. If these wells are uncapped, fugitive VOC emissions can result. Wells screened across the water table (if present) may act as conduits for air flow. Packing off the entire screened interval may reduce, but will not eliminate such bypassing, as air may still travel through the filter pack. Decommissioning such wells may be necessary.
7	Record periodic groundwater table measurements to document the site-specific impacts on the groundwater mounding/mixing.
8	Measure total pressure and flow measurements after the system stabilizes and measure the pressure or vacuum at gas probes and water table wells to evaluate the site for subsurface air pressure/vacuum.

TABLE 6-2 (Cont'd)

IAS System Start-up Procedures

9	IF ANY POSITIVE SUBSURFACE AIR PRESSURE READINGS AND/OR HIGH LEVELS OF VAPOR PHASE CONTAMINANTS ARE MEASURED IN VADOSE ZONE MONITORING POINTS ADJACENT TO BUILDINGS OR OTHER STRUCTURES THAT MAY ACCUMULATE POTENTIALLY HAZARDOUS VAPORS, SYSTEM OPERATORS SHOULD IMMEDIATELY RE-EVALUATE THE OPERATIONAL PARAMETERS OF THE SPARGING SYSTEM. DISCONTINUE OPERATION OF THE AIR SPARGING SYSTEM IF CONDITIONS ARE DEEMED UNSAFE.
10	Repeat the previous steps for each of the IAS well groups, as appropriate.

[1] Derived in part from Marley and Bruell (1995).

(d) vacuum distribution in the unsaturated zone (if an SVE system is in operation);

(e) groundwater elevations in monitoring wells;

(f) pressure distribution in the saturated zone;

(g) dissolved contaminants of concern; and

(h) non-specific groundwater chemistry parameters (e.g, redox potential, BOD, and COD).

b. System Operating Strategies.

(1) When operating IAS systems, two prevalent limitations for system effectiveness can occur: (a) kinetics of mass transfer at the air/water interface, or (b) the rate of mass transfer of the contaminant from the water phase to the air/water interface. Marley and Bruell (1995) are among those who state that although continuous operation may be adequate under most circumstances, pulsed operation can be used to assist with agitation and mixing of the water as air channels form and collapse during each cycle. While some argue that pulsed operation should be considered the default strategy, others are less enthusiastic and suggest that while pulsed injection may increase the air/water contact, the overall effects on groundwater mixing may be modest (Johnson 1994).

(2) Pulsed operation includes cycling equipment operation at specified intervals. A properly timed pulsed operation could deliver enhanced performance. If an IAS interception system is being used, pulsed operation should allow groundwater to approach, during shutdown periods, its natural rate and direction and bring more contaminated water into the IAS ZOI. The correct operating method should be evaluated on a site-by-site basis.

(3) There has been considerable debate over the issue of whether to cycle remediation systems to optimize the recovery of hydrocarbons in the saturated and unsaturated zones. In groundwater pump-and-treat systems, cycling was believed by its advocates to be more effective than continuous pumping for removing hydrocarbons and minimizing the "tailing" effect so commonly reported during the operation of these systems (Armstrong et al. 1994). A similar approach was suggested for the operation of SVE systems. However, studies suggest that low flow, continuous blower operation appears to be a more efficient means of removing hydrocarbons from the subsurface (Bahr 1989). The increased removal efficiency is related to the fact that mass transfer is enhanced, because under continuous extraction the maximum concentration gradient is maintained.

(4) Pulsed injection involves a different rationale and approach. Some investigators have cycled sparge systems by varying the injection pressures or by simply turning the system on and off, known as pulsing (Marley et al.

1992a; Johnson et al. 1993). The conceptual model suggests that air channels will form in pathways with the largest pore diameters (Ahlfeld et al. 1994). As long as the pore geometry remains the same from one pulse cycle to the next, air pathways should remain constant (assuming that secondary fractures do not develop due to overpressurization). McKay and Acomb (1996) found that air distribution profiles measured with a neutron probe were repeatable with each cycle of operation. Even if the presence of residual air saturation following a cycle initially blocks the displacement of water during the next cycle, airflow evidently becomes reconsolidated within the same preferred channels each time, at least insofar as where the airflow channels terminate at the ground surface (Leeson et al. 1995). Pulsed operation intermittently reproduces the expansion phase (Fig. 4-5A,B) during which air-filled saturation values appear to be maximized over the largest subsurface volume (McKay and Acomb 1996). Therefore pulsed operation may produce a somewhat larger ZOI than continuous operation.

(5) It appears (paragraph 2-7a) that pulsing promotes: 1) groundwater mixing in the vicinity of air channel locations, and 2) mass transfer of air into the water phase. Groundwater mixing is established as air channels form and collapse during a given cycle. This process reduces the degree to which diffusion governs mass transfer, resulting in an increase in mass transfer of hydrocarbons from water to the air phase (Wisconsin DNR 1993). Figure 6-1 provides an example of enhanced mass removal resulting from pulsed sparging (Clayton et al. 1995). The transient mounding period has been proposed as a design parameter for the frequency of pulsing. Balancing of flows to individual IAS wells, if determined to be critical to the IAS system, can either be autoregulated or frequently monitored, with valves adjusted as necessary. Cycling from one sparge well to another using the same compressor is expected to provide a cost savings because of smaller gas compressor requirements and reduced energy costs (Marley et al. 1994). Pulsing can also be an economic and desirable approach for use during biosparging applications.

(6) It should be noted that at locations that are well suited to IAS (i.e., lack of confining layers) pulsing is not expected to cause groundwater to migrate in new directions. Consideration must still be given to what, if anything, can cause contaminant migration and how to avoid it.

c. Biological Monitoring. The progress of a biosparging remediation can be assessed through a variety of means, including biological monitoring. Microbial counts, for example, are likely to rise as remediation proceeds (Table 3-4), because IAS may stimulate the growth of microbes. To monitor microbial activity, heterotrophs as well as specific degraders are often enumerated. Beyond a point, there may be little benefit in attempting to increase biomass because increased biomass may retard flow through the subsurface. The population density of the specific degraders is often limited by factors such as mass transfer of electron acceptors (e.g., oxygen), electron donors (e.g., hydrocarbon), and nutrients (e.g., nitrogen and

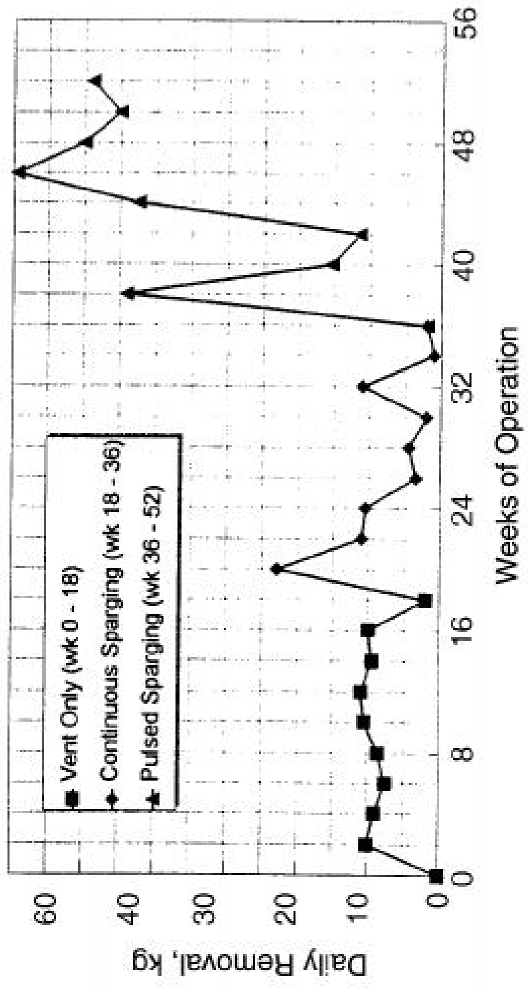

Figure 6-1. Mass removal rates were greatly improved by pulsed sparging relative to earlier periods when venting only and continuous sparging had been implemented (Clayton et al. 1995)

phosphorus). Rates of desorption and dissolution of hydrocarbons may also limit microbial activity. Biological monitoring may contribute to understanding the limiting factor(s) and aid in deciding whether to pursue actions such as nutrient addition.

d. System Operating and Monitoring Procedures. A properly operated and monitored system is required to achieve project objectives. The following sections provide details to assist an operator with the proper operation of an IAS system. The first few months of system operation are critical to ensure that accidental spreading of VOCs does not occur and to measure system performance.

(1) Equipment. As shown on Tables 6-3a, 6-3b, and 6-3c, specific measurements must be made to develop an understanding of system operations, trends and effectiveness. These tables have been separated into system measurements, general inspection, and system maintenance. All equipment must be operated in accordance with manufacturer's recommendations. Pressure readings can be measured with manometers, diaphragm pressure gauges, or pressure transducers. Responsible individuals should discuss any deviations noted during O&M operations and temporarily shut-down systems as warranted. Blower amperage should be monitored to determine the loads placed on the equipment. Excessive amperage could result in damage to the equipment due to overheating.

(2) Monitoring Frequency. The frequency of monitoring of an IAS/Biosparging system is specific to the site and remediation strategy. Before implementing an IAS/Biosparging system, it is important for the design team to establish data quality objectives that are appropriate for monitoring the progress of the system relative to site specific target cleanup levels. Once the system is installed, baseline data may be collected and subsequently future data needs are identified. A Sampling and Analysis Plan and Quality Assurance Project Plan should be prepared that establishes both monitoring methods and frequency as described in EM 200-1-3.

(3) System Operating Modifications. As previously stated, initial operations and monitoring are critical. It is important to detect, quantify and correct problems (as necessary) which may have arisen initially. After data collection, detailed emphasis must be placed on interpretation of results and appropriate actions taken for system optimization. Monthly comparisons of results versus project goals must be obtained and tracked.

(4) Recordkeeping. A formal data management system is recommended. Information collected, as outlined herein, must be tracked. Collected information must reference date, time and location for all data, with appropriate comments noted.

TABLE 6-3a

Example IAS System Operational Checklist
Mechanical System Measurements

Inspector name:		Date:	

ITEM	TIME CHECKED	TYPICAL VALUES*	INITIAL READING	READING AFTER ANY ADJUSTMENTS
Compressor/Blower Discharge Pressure		8 psi		
Compressor/Blower Discharge Flow @ Pressure Above		100 cfm		
Sparge Blower Discharge Temp.		240° F		
Bearing Oil Temperature		200° F		
Bearing Oil Pressure		20 psi		
Interval Operating Hours		---		---
Motor Amps		8		
Oil Level		---		
Aftercooler Inlet Pressure		7 psi		
Aftercooler Inlet Temperature		180° F		
Aftercooler Outlet Pressure		6 psi		
Aftercooler Outlet Temperature		120° F		
Ambient Air Temperature (outside/inside shed)		---		---
IAS-1[1] Wellhead Pressure		5.5 psi		
IAS-1[1] Wellhead Air Flow		6 cfm		
IAS-2[1] Wellhead Pressure		7.4 psi		
IAS-2[1] Wellhead Air Flow		2 cfm		

NOTES:
1. EACH OTHER IAS WELL SHOULD BE LISTED INDIVIDUALLY
2. OPERATOR SHOULD OPERATE VALVES AND CONTROLS AT LEAST ONCE EACH MONTH

* Values shown for example only, column to be filled in according to actual typical measurements

TABLE 6-3b

Example IAS System Checklist
General Inspections

Inspector name:	
Date:	

ITEM	TIME CHECKED	NORMAL SITUATION*	OBSERVATIONS
Shed/trailer lock		locked	
Mechanical Equipment		all IAS blowers operating	
Equipment Housing		no rattling	
System By-pass Valve		closed	
System Flow Valves		0.5 open	
Electrical Controls		all go	
IAS Well Heads		all intact	

NOTES:

1. OPERATOR SHOULD OPERATE VALVES AND CONTROLS AT LEAST ONCE EACH MONTH

* Situations shown for example only, column to be filled in according to operational plans

TABLE 6-3c

Example IAS System Checklist
Equipment Maintenance

Inspector name:	
Date:	

ITEM	TIME CHECKED	MAINTENANCE PERFORMED	MINIMUM SCHEDULE*
Oil Change			biannually
Oil Filter Change			quarterly
Air Filter Change			monthly or diff. pressure > 15 " water
Activated Carbon Drums			quarterly or diff. pressure > 5 psi
Moisture Separator Tank			quarterly
Blower Lubrication			every 1000 hrs.

Comments/observations:

INSTRUCTIONS:

1. OPERATOR SHOULD OPERATE VALVES AND CONTROLS AT LEAST ONCE EACH MONTH

* Schedules shown for example only, minimum maintenance must be set according to equipment specifications.

(5) Operator Training. Formal operator training is needed to adequately prepare site operators to safely and effectively operate and maintain IAS systems. Training should include both hands-on and classroom training.

(6) Troubleshooting. There are several mechanical components for an IAS system which are subject to operating problems. These include filters, pumps, valves, control systems and mechanical units. Table 6-4 has been developed to use as a guide for operating strategy and to evaluate potential solutions. This table assumes the use of an SVE system in conjunction with the IAS system.

(7) As-built and O&M Plans. As-built and O&M plans should be developed upon system completion to use for long term monitoring and effectiveness evaluations. An as-built plan should include the following at a minimum:

(a) boring logs;

(b) well construction diagrams;

(c) locations of IAS wells;

(d) piping, manifold, valve, instrumentation, equipment and sampling locations;

(e) process schematic as actually configured with all manual/automatic controls explained (including controller logic)

(f) contaminant source and extent locations, if applicable; and

(g) site information including scale, north arrow, legend, title block and groundwater flow direction.

The system O&M manual will constitute a very important document for the project. It must be written in an understandable format and contain a description of all activities (including specific checklists) to be performed along with detailed contingency plans and training requirements. Table 6-5 is a general outline of topics to be covered in an IAS O&M manual.

TABLE 6-4
IAS System Operation
Strategy and Troubleshooting Guide

Problems	Considerations	Potential Solutions
The zone of influence is insufficient or not as predicted.	The soil may be less permeable in some locations or there may be preferential flow.	Further subsurface investigation. Readjust flows. Additional wells. Higher IAS well density. Check wells for clogging. Check for short circuiting.
Groundwater levels are spatially inconsistent.	There may be preferential flow or heterogeneities.	Further subsurface investigation. Additional wells. Seal preferential pathways.
Increasingly high injection pressures.	Potential well fouling.	Clean wells. Purge manifold lines.
The VOC concentrations have been reduced in some but not all wells.	Treatment may be completed in some areas of the site.	Reduce flows to some wells. Take some wells off-line. Check for ongoing sources of contamination. Check for rebound.
The VOC concentrations remain consistently high despite high mass removal rates.	Undiscovered groundwater contamination of free-phase product or DNAPL.	Further investigation. Product recovery. Shift approach.
Low concentrations of VOCs are extracted during operation, but high concentrations reappear when system is shut off.	Diffusion limitations, flow short-circuiting due to preferential flow, airflow rates higher than necessary.	Pulse sparging. Hot gas injection. Excavation of "hot spots" and ex-situ soil treatment.
A decline in concentration levels has made thermal/catalytic oxidation economically infeasible.	"Tailing" of the concentration versus time curve is a common occurrence.	Evaluate uncontrolled air emission. Activated carbon. Biofilters. Use other technologies to speed up removal. Possibly reduce airflow rates.
Poor SVE performance following large rain events.	The system is sensitive to the effects of soil moisture on air permeability and aeration.	Cap site. Dual recovery. Shut off system following major rain events.
Unexpectedly high vapor concentrations at or near explosive levels.	Free-phase product; accumulation of methane or other VOCs.	Dilute SVE intake air. Alter system to be explosion-proof. Check for unknown sources of contamination.

Table 6-5 Typical IAS O&M Manual

I. Introduction
- A. Purpose/Background
- B. Cleanup Goals
- C. Discharge Limits
- D. Description of Facilities
- E. Project Organization

II. Description of System Components
- A. Well Configuration and Construction Detail
- B. System Piping and Instrumentation
- C. Air Sparging Compressor/Blower
- D. Ancillary Equipment
- E. Controls

III. System Operation
- A. Start-up
- B. Routine Operating Procedures
- C. Troubleshooting

IV. System Maintenance
- A. Weekly Inspections
- B. Routine Maintenance Procedures
- C. Consumables and Spare Parts Inventory

V. Sampling, Analysis and Reporting Documentation
- A. Sampling and Analysis Schedule
- B. Reporting
- C. Quality Assurance

VI. Record Keeping, Data Management and Reporting
- A. Record Keeping and Data Management
- B. Alterations to Remediation System
- C. Revisions to the O&M Plan
- D. QA/QC Revisions

VII. Contingency Plan
- A. Mechanical Contingencies
- B. System Modifications
- C. Criteria for Triggering Corrective Action

VIII. Personnel Training

Appendix A - Health and Safety Plan

Appendix B - Standard Operating Procedures
- Air Sampling
- Water Sampling
- Water Level Measurement